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Burrowing Nematode, a Major Pest in the Tropics

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The burrowing nematode is a serious pathogen that infects a wide range of plants grown in Hawaii. As a quarantine pest, the nematode is a problem in greenhouse-grown export foliage plants. In field-grown banana, anthurium, and other crops, the burrowing nematode reduces crop yield. These two situations, quarantine losses and yield reduction, require different management approaches.

Burrowing nematode, *Radopholus similis*, is an obligate parasite of plants. An adult nematode is only about $^{3}/_{100}$ inch (0.75 mm) long, invisible to the naked eye. The nematode reproduces sexually, and females lay eggs as they migrate through root tissue or, in some plants, even shoot tissue. The eggs mature in about 21 days given the proper environmental conditions. The nematodes may leave the plant tissue at any time and then reinfect it or another plant, or the nematode may spend its entire life inside a single plant.

The burrowing nematode has a very wide host range. It has been recovered from over 50 different plant genera. It is usually associated with root tissues, but in anthurium, calathea, and agloanema it is also able to move and feed in the shoot tissues. The nematode moves both inter- and intracellularly, feeding with its stylet on cortical tissue. The destruction of plant cells by nematode feeding leads to the formation of the typical lesions attributed to the burrowing nematode.

Symptoms and plant damage

Roots or rhizomes usually have a dark, sunken lesion where the nematodes have fed. Other below-ground tissue such as corms and tubers may be free of lesions but will lack feeder roots. Burrowing nematode tissue damage provides an entry point for certain fungi and bacteria that cause the root tissue to rot. A complete loss of below-ground tissues is not uncommon in severe rots.

Above-ground symptoms are not reliable for diagnosis because they resemble those of nutrient deficiencies and water stress. Host plants are seldom killed. Rather, the plants are stunted, lack vigor, and grow slowly.

In "anthurium decline," the burrowing nematode causes anthurium leaves to turn yellow and plants to remain small. The diseased anthurium plants live for several years but yield fewer and smaller flowers.

"Toppling disease" of banana illustrates another aspect of burrowing nematode damage. Severely infected banana plants topple in wind or under the weight of a developing bunch because anchor roots have been destroyed. Under low levels of infection, water and nutrient uptake are reduced, reducing banana yield.

In pepper, leaves turn yellow, droop, and may even be shed in "yellows" or "slow-wilt," but the plants usually do not die until 3–5 years after initial nematode infection.

Anthurium plants grow poorly when infected with burrowing nematodes—compare the healthy plant at left with the others, which are successively more infected.

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"Spreading decline" of citrus results in foliage becoming sparse and branches dying. Citrus may wilt under drought conditions, but this usually is not evident until a year after initial infection.

Export greenhouse crops

The burrowing nematode is a quarantine pest in the United States in Arizona, California, Louisiana, New Mexico, and Texas. Its importation into Bermuda, Chile, the European Community, Japan, and Mexico is also prohibited. To minimize the risk of burrowing nematode introduction into quarantined areas, plants for export must be grown in certified greenhouses under strict sanitation. The detection of a single burrowing nematode can result in rejection or destruction of the shipment at the port of entry and suspended operations at the originating nursery pending recertification. Infestations of burrowing nematode in certified greenhouses usually result from

- propagation of infected mother plants
- introduction of infected plants
- contaminated potting media
- contaminated pots, benches, or other nursery equipment
- contaminated irrigation water
- infected plants and weeds in and around the nursery

Control

The mere presence of the burrowing nematode is of greater concern than potential plant damage that may result from the infection. Consequently, the tactics employed to maintain nematode-free plants differ from tactics used to reduce damage to the plants. The primary control for burrowing nematode in any nursery operation is to begin with clean plants and clean potting media. Thereafter, good sanitation is critical. Key steps to follow in this protocol are as follows.

Nursery infrastructure

Bench construction and maintenance should be designed to-minimize moss and algae growth. The perimeter and inside of the house should be free of weeds.

Planting material

Mother plants should be checked annually for the presence of nematodes. Plant material should be purchased only from suppliers who maintain standards that ensure nematode-free stock. It would be prudent to assay every purchase before introducing the material into a certified greenhouse. Tissue-cultured plants that are received in flasks and transplanted on site will be free of nematodes.

Irrigation water

Potable water generally will not contain burrowing or other plant-parasitic nematodes. Irrigation water from ditches and catchment systems should be treated, filtered, or assayed for nematodes regularly.

Potting media

Most commercial potting mixes will be free of plant-parasitic nematodes. Sphagnum peat moss may contain nonparasitic nematodes. Cinders from vegetation-free areas are usually free of nematodes. Equipment used to haul cinders to the nursery should be clean and free of soil.

Worker training

Workers must be educated in the importance of nematode control protocols to ensure that mistakes are not inadvertently made and those that are receive prompt attention. Workers should also be taught to recognize any unusual plant growth or behavior such as stunting or early flowering.

When burrowing nematode infestations are discovered during routine samplings, relatively few therapeutic measures can be taken. Infected plants must be destroyed or removed to a separate greenhouse. Infected mother plants should be destroyed and new, clean propagation stock initiated. Some plants can be dipped or drenched with 120°F (49°C) water for 15 minutes to eliminate burrowing nematode infections. Nematicides that will eliminate nematodes in infected plants are not registered for use.

Burrowing nematode control in field crops

Burrowing nematodes have been recovered from many agricultural crops in Hawaii. The field crops most affected by burrowing nematode are banana, anthurium, coffee, ginger, and heliconia.

Damage to the plant from burrowing nematode is a function of the nematode population. Small nematode populations seldom inflict much plant damage, but large populations can be devastating (Note: Low numbers of nematodes will increase to high numbers on a good host). The goal of field control is therefore to limit the num-

bers of burrowing nematodes to which a plant is exposed. Because most of crops grown in Hawaii are perennial crops, the plants must be protected at planting and throughout the crop cycle.

Control in banana

Moderate infections on banana result in smaller bunches and reduced yield. Severe infections cause the roots to rot and the banana plants to become poorly anchored. Wind or the weight of the bunch may then cause the plant to "topple." Control is a two-phase process. The first phase occurs before planting (preplant) and the second phase occurs after the banana is established in the field (postplant).

Preplant control tactics are directed at ensuring low nematode numbers in the soil and nematode-free planting material. The planting area should be sampled for the presence of nematodes. Proper sampling methods are described in CTAHR publication PD-15. If nematodes are present in damaging levels, soil can be bare-fallowed or planted to a nonhost cover crop such as pangola grass or sunn hemp until the nematode population declines to below the damage threshold level. The field can be fumigated with a product such as Vapam® or Telone II®. Nonfumigant nematicides, such as Nemacur®, Mocap®, or DiTera®, are less effective than the other tactics but do provide some benefit. Read and carefully follow all pesticide labels.

All commercial banana cultivars are susceptible to burrowing nematode, thus the importance of nematode-free planting material can not be overemphasized. Clean planting material can be obtained from tissue-cultured plants or corms trimmed and treated with hot water. Suckers from the mother plant are likely to be infected with burrowing nematode if the mother plant is infected. Trimming the outer tissue and then submersing the corm in hot water until the internal temperature reaches 122°F (50°C) and holding that temperature for 15 minutes will kill any nematodes present.

Postplant control measures involve the application of nonfumigant nematicides. Nematicides labeled for use on banana are most effective when applied after harvest of a bunch rather than on a calendar basis. The application after harvest coincides with a flush of new root growth. The nematicides like Nemacur®, Mocap®, or DiTera®, will reduce nematode infection of the new roots, providing some protection to the plant.

Banana plants infected by burrowing nematode tend to topple where water drains or streams and when plants are close to harvest and heavy with fruit. Flowing or draining water undermines these plants. Some farmers use guy wires of nylon twine to anchor plants that are in danger of toppling so that the bunch may be harvested.

Control in anthurium

Because anthurium vigor and productive life is reduced by nematode infection, especially in young plants, control focuses on delaying the initial infection and reducing the number of nematodes in the medium.

Planting beds should be nematode-free or have a very low burrowing nematode population. Planting material must be nematode-free as well. The planting beds can be fumigated with Vapam® or Telone II®, according to label directions. Old nematode-infested cinder media can be removed and replaced with clean cinder. Tissue-cultured plants provide nematode-free planting material. If top-cuttings (gobos) are being used, they should be free of nematodes. Several cuttings should be assayed, and if nematodes are found the entire lot should be immersed in 120°F (49°C) hot water for 10 minutes to kill all nematodes.

After planting, nonfumigant nematicides such as Nemacur® or DiTera® need to be applied regularly if the nematode is present in the field. Multiple applications throughout the year are preferable to a single, annual application of nematicide. Postplant nematicide applications may need to begin as soon as 6 months after planting if plant growth is retarded.

Control in other crops (coffee, ginger, heliconia)

For other crops, control of burrowing nematode relies mostly on preplant practices. Planting material must be nematode-free. Ginger and heliconia rhizomes can be treated with hot water as with banana to eliminate nematodes. Coffee seedlings should be germinated and grown in a sterile medium. The area in which the crops will be planted should be assayed to determine if the nematode is present in damaging numbers. If the nematode exceeds the damage threshold, the field could be fallowed, planted with a nonhost cover crop, or fumigated as previously described.

For crops that will be harvested over many years, postplant control involves minimizing stress to the plant. Proper irrigation and fertilizer application can mitigate some nematode damage and yield loss.